

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of : Abdulsalam Al-Mayahi  
Serial No. : 10/566,389  
Filing Date : May 26, 2006  
Title : Solvent Removal Process  
Group Art Unit : 1797  
Confirmation No. : 3744  
Examiner : Ana M. Fortuna  
Attorney Docket No. : BOU-36620

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**DECLARATION OF DR ADEL SHARIF  
UNDER 37 C.F.R. §1.132**

I, Dr Adel Sharif, the undersigned Declarant, do hereby state and declare that:

1. From June 1998- to the present, I have been employed with the University of Surrey, UK. In my current position as Director of Centre for Osmosis Research & Applications, I am responsible for teaching and leading research in the area of osmosis science for applications in desalination and renewable power generation. I received my B.A. in Chemical Engineering from University of Baghdad, Iraq in 1986. I received my Ph.D. in Chemical Engineering from the University of Wales Swansea in 1992. I am one skilled in the art of the instant patent application.
2. I am intimately familiar with the above-referenced patent application (the '389 application). I am an inventor to the '389 patent application.
3. I have read the Examiner's Office Actions dated October 8, 2009 and May 24, 2010; International Publication No. WO97/18166 to Herron et al. (*Herron166*); U.S. Patent No. 4,781,837 to Lefebvre (*Lefebvre*); U.S. Patent No. 5,755,964 to Mickols (*Mickols*); U.S. Patent No. 5,281,430 to Herron et al. (*Herron430*); and U.S. Patent No. 5,098,575 to Yaeli (*Yaeli*). The patent publications are hereafter collectively referred to as *the cited references*.

4. The present invention is the result of our unexpected discovery that dissolved species in seawater or brackish water flow against the direct osmosis (DO) concentration gradient present between the first solution and the second solution. We call this phenomenon the "crossover effect" or "crossover." In crossover, dissolved species-flow from the first solution, through the DO membrane, and into the second solution. As explained below, the crossover of these ions causes fouling in the second solution, despite the fact that they themselves are *dissolved* in the first solution and therefore not responsible for fouling in the first solution.
5. Seawater and brackish water contain significant amounts of dissolved calcium ions,. These ions remain dissolved in the seawater/brackish water in the presence of counterions, such as chloride ions, since calcium chloride is a water-soluble salt. We unexpectedly discovered, however, that such ions crossover into the second solution and lead to fouling. The crossover is surprising, unexpected and counter-intuitive because the flow of dissolved species occurs against the bulk concentration gradient that exists between the first solution and the second solution in DO. The fouling is also surprising, unexpected and counter-intuitive because the second solution is especially tailored to be free from components that cause fouling. We have found that, although the calcium ions are soluble in the first solution, having crossed-over into the second solution, they precipitate with previously soluble counterions, such as sulfate, in the second solution, resulting in fouling.
6. The Examiner has suggested that the second solution contains salts such as hydrated magnesium sulfate that, if in contact with the membrane for a certain length of time, stick to the membrane and cause fouling. For this reason, the Examiner is of the view that it would have been convenient to the skilled artisan to provide scaling agents [*sic*] in the second solution to protect the membrane from scaling from the magnesium sulfate salts. We respectfully submit that the Examiner's contentions are technically without merit. Hydrated magnesium sulfate has a solubility in water of 710 g/l at 20 degrees C. It is therefore highly water-soluble (the solubility of sodium chloride in water at 25 degrees C is merely 359 g/l). Since our second solution is tailored to be substantially free from components that cause membrane fouling, any magnesium sulfate present in the second

solution is dissolved in solution and would therefore not cause fouling. Such salts, therefore, would not stick to membrane as the Examiner suggests. Contrary to the Examiner's suggestions, therefore, a skilled artisan would have no reason to wish to protect the membrane from magnesium sulfate scale, since magnesium sulfate is not a component that gives rise to fouling in the second solution.

7. Our invention is a solution to the heretofore unidentified problem of crossover. We add additives (anti-foulant and other) directly to the second solution. Direct addition of these additives to the second solution prevents *in situ* fouling in the second solution that results from crossover. Provision of these additives (i) enables effective performance of direct osmosis and (ii) enables the diluted second solution to undergo further recovery (*i.e.*, nanofiltration) without any additional treatment.
8. Turning to *the cited references*, none of *the cited references* contemplate, recognize or appreciate the phenomenon of crossover—and crossover in a direct osmosis system in particular. Each of *the cited references* is premised on the principle that the concentration gradient (or osmotic gradient) in direct osmosis prevents dissolved species from passing into the osmotic solution. With no recognition of the problems associated with crossover, none of *the cited references* provide any reason to introduce antifoulant directly into the second solution as in our invention.
9. *Herron430* has nothing to do with our invention. *Herron430* discloses a process for concentrating fruit juice using a corrugated membrane. *Herron430* discloses a stand-alone and separate maintenance operation whereby a membrane cleaning procedure recirculates Ultrasil solution for five minutes through the membrane followed by a water rinse in order to clean the pores of the membrane. *Herron430*, col. 14 lines 35-41. This “recirculation” in *Herron430* requires the entire osmotic production process of *Herron430* to shut down and entails flowing the Ultrasil cleaner across the membrane's surface. The Ultrasil cleaning procedure is not part of the *Herron430* osmotic concentration process because the Ultrasil would negatively effect the taste and the composition of the *Herron430* finished concentrated juice product. Our invention, on the other hand, is different than the Ultrasil cleaning procedure because we add additives

(antifoulant and other) directly to the second solution. Our additives remain in the second solution and do not flow to the first solution.

10. The Examiner's statement that the second solution contains salts that cause fouling is not accurate. We create the second solution with a known composition. We use compositions in the second solution that do not cause fouling. The solute species listed in claim 49, for example, do not, by themselves, produce fouling in the second solution. It is crossover ions in combination with the second solution that causes *in situ* fouling in the second solution (in the absence of our additives).
11. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this Rule 132 Declaration is directed.

Dated: 16/08/2010

Prof. ADEL SHARIF  
NAME

